(19) JAPANESE PATENT OFFICE

PATENT ABSTRACTS OF JAPAN

(11) Publication number: 2000188440 A

(43) Date of publication of application: 04.07.00

(51) Int. Cl H01S 5/227
H01L 33/00

(21) Application number: 10365645

(22) Date of filing: 22.12.98

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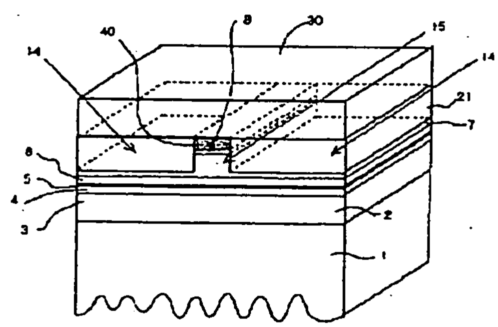
(54) SEMICONDUCTOR LASER AND ITS MANUFACTURE

(57) Abstract:

PROBLEM TO BE SOLVED: To prevent an element from being damaged due to contact of a ridge with a heat sink by laminating a cladding layer and a contact layer on a laser structure in this order, forming ridge stripes on the top of flat areas on both sides, and forming a buried layer in the stripes out of polycrystalline insulating material.

SOLUTION: A ridge-type semiconductor laser consists of a structural layer comprising a cladding layer 3 of n-type AlGaN, a guide layer 4, an active layer 5, a guide layer 6, and a cladding layer 7 of p-type AlGaN. This structural layer is formed by forming a current path layer 2 of n-type GaN on a sapphire substrate 1, forming flat areas 14 on both sides of the cladding layer 7 and ridge stripes 15, and forming a contact layer of p-type GaN and electrodes 40 and 30 on the flat top of the stripes 15. A buried layer 21 is formed in the stripes 15 on the both-side flat areas 14 using a polycrystalline insulating material of AlN having a lower refractive index than that of the laser structural layer. Since the buried layer 21 is polycrystalline, cracking due to a difference in lattice constant does not occur between it and the AlGaN portions.



CLAIMS

[Claim]
[Claim 1] The process which is the manufacture technique of the ridge type semiconductor laser which has a ridge stripe, and forms the laser substrate which carried out the laminating of the clad layer and the required contact layer of a ridge stripe material to order on the laser structure layer on a laser structure layer, The process which forms the stripe electrode of a ridge stripe pattern on the aforementioned clad layer and a required contact layer that the ridge stripe which projects from a both-sides flat part and these, and has the flat top section should be formed, The process which carries out the etching of the parts for a clad layer other than the clad layer covered by the aforementioned stripe electrode, and forms a ridge stripe and a both-sides flat part, The embedding stratification process which forms the embedding layer which deposits the polycrystal insulating material which makes a principal component AlN which has a refractive index lower than the refractive index of a laser structure layer on the aforementioned both-sides flat part, and sandwiches the aforementioned ridge stripe, The semiconductor laser manufacture technique characterized by including the process which removes the layer on the aforementioned stripe electrode, is made to expose the aforementioned stripe electrode, and forms the flat top section, and the process which forms an electrode on the aforementioned flat top section.
[Claim 2] The semiconductor laser manufacture technique of the claim 1 publication characterized by being the multilayer to which the aforementioned laser structure layer makes a principal component 1(AlxGa1-x)-yInyN (0<=x<=1, 0<=y<=1).
[Claim 3] The aforementioned embedding stratification process is the claim 1 characterized by including a spatter process, or the semiconductor laser manufacture technique given in two.
[Claim 4] Semiconductor laser characterized by having the embedding layer which deposits the polycrystal insulating material which makes a principal component AlN which has a refractive index lower than the refractive index of ridge type semiconductor laser ****** which has a both-sides flat part and the ridge stripe which has the flat top section which is projected from these, and by which an electrode is formed on a laser structure layer, and a laser structure layer on the aforementioned both-sides flat part, and sandwiches the aforementioned ridge stripe.
[Claim 5] Semiconductor laser of the claim 4 publication characterized by being the multilayer to which the aforementioned laser structure layer makes a principal component 1(AlxGa1-x)-yInyN (0<=x<=1, 0<=y<=1).
[Claim 6] The polycrystal insulating material which makes the above AlN a principal component is semiconductor laser the claim 4 characterized by being AlN, or given in five.

DETAILED DESCRIPTION

[Detailed description]
[0001]
[The technical field to which invention belongs] this invention relates to semiconductor laser and its manufacture technique.
[0002]
[Prior art] Semiconductor laser is known as an element which it is used for the light source of optical-pickup equipment of in read-out / optical information record regenerative apparatus to write in for a signal from an optical disk, and also may be applied to optical transmission systems, such as optical CATV, the pump light source of high-density information record SHG short wavelength laser or small solid state laser, an optical instrumentation field, etc. In order to operate by the small current and to perform a longitudinal direction single-mode oscillation, it is necessary to confine the electron, the electron hole, and oscillation light in a semiconductor in a parvus field. In the pn junction perpendicular direction, it has shut up by double hetero structure etc. Although there is gain **** structure as technique of restricting the photogenesis field of laser, about orientation parallel to a junction, in order that a front may generally be distorted and astigmatism may come out of this, for the intended use of the light source for disk read, the semiconductor laser of refractive-index **** structure is used. Refractive-index **** structure is the structure where carry out forming not only a junction perpendicular direction but a ridge stripe etc., and a junction parallel direction also faces across a photogenesis field at the charge of a clad plate with a low refractive index.
[0003] Since the effective refractive index to the light which spreads the guide layer of the ridge lower part will become large a little from the other fraction if a part of clad layers other than the fraction of a current injection field are removed by etching etc. and a ridge stripe is formed, light is shut up by the ridge lower fraction. An electrode is prepared in the ridge upper part, and a current is poured in and it is made to oscillate between an electrode and a substrate in ridge type semiconductor laser.
[0004]
[Object of the Invention] On the other hand, occurrence of heat becomes a problem when using semiconductor laser by continuous oscillation. Then, in order to improve thermolysis, mounting of the so-called junction down the electrode of the ridge upper part is contacted [the down] to a heat sink is performed. Since the width of face of the projected ridge fraction is several [only] micrometers when it is going to perform

this installation technique, there is a problem by which an element will be destroyed in this ** with a heat sink.

[0005] Then, the need of carrying out the flattening of the side from which the ridge stripe fraction of laser is made arises. It embeds to the almost same height as a ridge stripe fraction, and considers forming and carrying out the flattening of the layer. However, in SiO2, along with the side attachment wall of the ridge section, it had to form thinly, the flattening was difficult, and selection of an embedding material was difficult.

[0006] Then, it aims at offering the ridge type semiconductor laser which has a ridge stripe on the laser structure layer which can be equal to junction down mounting, and its manufacture technique in this invention.

[0007]

[The means for solving a technical problem] The process which this invention is the manufacture technique of the ridge type semiconductor laser which has a ridge stripe on a laser structure layer, and forms the laser substrate which carried out the laminating of the clad layer and the required contact layer of a ridge stripe material to order on a laser structure layer, The process which forms the stripe electrode of a ridge stripe pattern on the aforementioned clad layer and a required contact layer that the ridge stripe which projects from a both-sides flat part and these, and has the flat top section should be formed, The process which carries out the etching of the parts for a clad layer other than the clad layer covered by the aforementioned stripe electrode, and forms a ridge stripe and a both-sides flat part, The process which forms the embedding layer which deposits the polycrystal insulating material which makes a principal component AlN which has a refractive index lower than the refractive index of a laser structure layer on the aforementioned both-sides flat part, and sandwiches the aforementioned ridge stripe, It is characterized by including the process which removes the layer on the aforementioned stripe electrode, is made to expose the aforementioned stripe electrode, and forms the flat top section, and the process which forms an electrode on the aforementioned flat top section.

[0008] In the manufacture technique of the semiconductor laser of this invention, it is characterized by being the multilayer to which the aforementioned laser structure layer makes a principal component 1(AlxGa1-x)-yInyN (0<=x<=1, 0<=y<=1). In the manufacture technique of the semiconductor laser of this invention, it is characterized by the aforementioned embedding stratification process including a spatter process.

[0009] The semiconductor laser of this invention is characterized by having the embedding layer which deposits the polycrystal insulating material which makes a principal component AlN which has a refractive index lower than the refractive index of ridge type semiconductor laser ****** which has a both-sides flat part and the ridge stripe which has the flat top section which is projected from these, and by which an electrode is formed on a laser structure layer, and a laser structure layer on the aforementioned both-sides flat part, and sandwiches the aforementioned ridge stripe.

[0010]

[Gestalt of implementation of invention] Hereafter, the example of this invention is explained, referring to a drawing. First, the ridge stripe embedding technique in the n type semiconductor layer in the ridge type semiconductor laser which has a ridge stripe is explained. Ridge type semiconductor laser is shown in drawing 1 . This ridge type semiconductor laser has the laser structure which consists of the clad layer 3 of n

type AlGaN, the guide layer 4 of n type GaN, the barrier layer 5 of InGaN, a guide layer 6 of p type GaN, and a clad layer 7 of p type AlGaN. A laser structure layer is a multilayer which makes a principal component 1(AlxGa1-x)-yInyN (0<=x<=1, 0<=y<=1). In order to form this laser structure layer on the silicon on sapphire 1 in which the current path layer 2 of n type GaN was formed and to shut up light, the ridge stripe 15 for which the clad layer 7 of p type AlGaN projects from the both-sides flat part 14 into which it was etched, and these is formed on the laser structure layer. Moreover, the contact layer 8 of p type GaN, and the stripe-like 2nd electrode 40 are formed in the flat top section of the ridge stripe 15, and the p lateral electrode 30 is further formed on it.

[0011] This ridge type semiconductor laser has the embedding layer 21 which sandwiches the ridge stripe 15 which deposited the polycrystal insulating material which makes a principal component AlN which has a refractive index lower than the refractive index of a laser structure layer on the both-sides flat part 14. Although the polycrystal insulating material which makes AlN of this embedding layer a principal component was AlN in this example, in the case of the III-V group of the usual conventional material system used for semiconductor laser, the laser itself and the thing of large composition of the band gap of the same crystal material system were used as an insulating material for embedding layer 21 of the above. Since the refractive index became small, large composition of a band-gap value also produced the effective-refractive-index step by this, and was also able to perform eye ********.

[0012] Moreover, since perfect grid matching was conventionally acquired between the embedding layer 21 and laser structure in the case of the material system, the epitaxial re-growth without the continuous crystal defect was possible. In the case of the conventional nitride semiconductor laser, the material composition which should be used for the embedding layer 21 is AlxGa1-xN, to proportion y of AlyGa1-yN of the clad layer in which this proportion x constitutes laser structure, unless it is x>y, a desirable light closes and eye ** is not obtained. Generally, in AlzGa1-zN, unlike AlGaAs system, a lattice constant becomes small with the increase in proportion z. Therefore, a tensile stress strong against the embedding layer 21 will occur. Consequently, a crack will occur at the time of re-growth of the embedding layer 21, and a crack will be spread also for the ridge stripe 15. A crack occurs because it is made to form by the epitaxial growth grids connected and grow up to be.

[0013] Although what is necessary will be just to form the conventional embedding layer 21 by SiO2 (glassy) etc., there are three problems in this case. Heat conduction bad (0.014 W/cmK) very much, and SiO2 checks [1st] thermolysis of semiconductor laser. The coefficient of thermal expansion of SiO2 gives [2nd] distortion extremely to the semiconductor laser element itself by the parvus's (5x10-7 deg-1). The expansion coefficient of GaN is 5.6x10-6. It is because it is deg-1. Therefore, SiO2 thickness cannot be thickened but the flattening is difficult. a refractive-index difference is too large and the refractive index of SiO2 tends to become [3rd] too (about 1.46) small a high order (width -- high order) mode oscillation.

[0014] Then, at the semiconductor laser of this invention, it is going to perform this embedding by the polycrystal insulating material which makes AlNs, such as AlN of a polycrystal, a principal component. Since the embedding layer 21 is polycrystal, the crack by the difference of a lattice constant does not occur between AlGaN fractions

which are laser structure. The physical-properties value of an embedding layer material is shown in Table 1.

[0015]

[Table 1]

Thermal conductivity A coefficient of thermal expansion Refractive index AlN (single crystal) 2.85 W/cmK 2.15 AlN (polycrystal) 1.7 W/cmK 4.3x10-6 deg-1 SiO2 0.014 W/cmK 5x10-7 deg-1 1.46 GaN (single crystal) 1.3 W/cmK 5.6x10-6 Since deg-1 2.8 and AlN are usually insulators, the embedding layer 21 does not transmit a current at all. Therefore, it is hard to produce the problem of the parasitic capacitance produced when it embeds by the n-type semiconductor like before.

[0016] As mentioned above, since the advantage of this invention which used AlN for the embedding layer 21 is good, its thermal conductivity is advantageous to thermolysis, and it is more moderate than a low refractive index and SiO2 from GaN at the high refractive index. [of thermal conductivity] Moreover, occurrence of asymmetry according [a coefficient of thermal expansion] to quite near and heat is suppressed by GaN of laser structure. Since AlN is a nearly perfect insulator, it does not have the leak of a current and does not have the parasitic-capacitance occurrence based on excessive pn junction. Furthermore, the advantage of this invention does not have occurrence of the crack resulting from grid mismatching, in order to form the embedding layer 21 in the shape of polycrystal by the spatter technique etc. In case of the embedding process, the high equipment of a running cost like CVD kiln is unnecessary.

[0017] Below, the example of the technique of producing the semiconductor laser of GaN system is explained from drawing 2 to up to the silicon on sapphire by this invention based on drawing 10. As shown in drawing 2 , the wafer of silicon on sapphire 1 is prepared and clarification of the front face is carried out by the organic solvent etc. on it first, by the predetermined epitaxial growth technique, the organic-metal vapor growth, the molecular-beam grown method, etc. The current path layer 2 of n type GaN, the clad layer 3 of n type AlGaN, the guide layer 4 of n type GaN, the barrier layer 5 of InGaN, the guide layer 6 of p type GaN, the clad layer 7 of p type AlGaN, and the contact layer 8 of p type GaN are ****ed in this order, and a laser substrate wafer is produced. Moreover, in growth of the guide layer 6, the clad layer 7, and the contact layer 8, Mg is doped that it should consider as p type. In addition, you may prepare AlN buffer layer (not shown) between silicon on sapphire 1 and the current path layer 2 of n type GaN.

[0018] Next, since the layer which carried out Mg dope is insulation if it remains as it is, it heat-treats a substrate wafer in N2 gas, and forms the guide layer 6, the clad layer 7, and the contact layer 8 into p mold. Next, nickel is made to -ed ** by resistance heating vacuum evaporationo all over contact layer of wafer 8. Next, as shown in drawing 3 , patterning of the nickel layer 9 is carried out using the usual process by the photoresist and wet etching.

[0019] Next, as shown in drawing 4 , reactive ion etching (RIE) using Cl2 gas performs dry etching, using the nickel layer 9 as a mask, it removes to the clad layer 3 of n type AlGaN, and the current path layer 2 of n type GaN is exposed. Next, a photoresist layer is applied, and by wet etching, as shown in drawing 5 , the pattern of the photoresists 17a and 17b for formation of the fraction which should serve as a ridge stripe, p lateral-electrode section, and n lateral-electrode section is made.

Especially photoresist 17a leaves predetermined width of face for the nickel layer 9, and it is used in order to form the 2nd electrode 40 of the shape of a stripe of nickel layer.

[0020] Next, as shown in drawing 6 , the 2nd electrode 40 of photoresist 17a and nickel is used as a mask, by the dry etching of RIE using Cl2 gas, the etching of a part of contact layer 8 of p type GaN and clad layer 7 of p type AlGaN is carried out, and the stripe 15 of the ridge section is formed. At this time, etching is stopped in the middle of the clad layer 7 of p type AlGaN.

[0021] Next, as shown in drawing 7 , it forms so that a polycrystal AlN layer may be made to deposit to the level of the top of the 2nd electrode 40, that is, the embedding layer 21 and the 2nd electrode 40 of the ridge stripe 15 may become the same height by the reactive sputtering system using aluminum target, N2 gas, and Ar gas. Next, as shown in drawing 8 , elimination liquid removes photoresists 17a and 17b, this removes AlN layer which suited on each resist pattern by the lift off, and the 2nd electrode 40 of nickel and a part of current path layer 2 of n type GaN are exposed.

[0022] next -- the nickel 2nd electrode 40 top exposed as shown in drawing 9 -- for the n lateral electrode 31, vacuum deposition of the electrode material is carried out to the order of Ti and Au on the current path layer 2 of n type GaN in the order of Cr and Au for the p lateral electrode 30, and electrode formation is carried out, respectively Then, semiconductor laser is completed by the predetermined process.

[Translation done.]

TECHNICAL FIELD

[The technical field to which invention belongs] this invention relates to semiconductor laser and its manufacture technique.

[Translation done.]

PRIOR ART

[Prior art] Semiconductor laser is known as an element which it is used for the light source of optical-pickup equipment of in read-out / optical information record regenerative apparatus to write in for a signal from an optical disk, and also may be applied to optical transmission systems, such as optical CATV, the pump light source of high-density information record SHG short wavelength laser or small solid state laser, an optical instrumentation field, etc. In order to operate by the small current and to perform a longitudinal direction single-mode oscillation, it is necessary to confine the electron, the electron hole, and oscillation light in a semiconductor in a parvus field. In the pn junction perpendicular direction, it has shut up by double hetero structure etc. Although there is gain **** structure as technique of restricting the photogenesis field of laser, about orientation parallel to a junction, in order that a wave front may generally be distorted and astigmatism may come out of this, for the intended use of the light source for disk read, the semiconductor laser of refractive-index **** structure is used. Refractive-index **** structure is the structure where carry out forming not only a junction perpendicular direction but a ridge stripe etc., and a junction parallel direction also faces across a photogenesis field at the charge of a clad plate with a low refractive index.
[0003] Since the effective refractive index to the light which spreads the guide layer of the ridge lower part will become large a little from the other fraction if a part of clad layers other than the fraction of a current injection field are removed by etching etc. and a ridge stripe is formed, light is shut up by the ridge lower fraction. An electrode is prepared in the ridge upper part, and a current is poured in and it is made to oscillate between an electrode and a substrate in ridge type semiconductor laser.

[Translation done.]

TECHNICAL PROBLEM

[Object of the Invention] On the other hand, occurrence of heat becomes a problem when using semiconductor laser by continuous oscillation. Then, in order to improve thermolysis, mounting of the so-called junction down the electrode of the ridge upper part is contacted [the down] to a heat sink is performed. Since the width of face of the projected ridge fraction is several [only] micrometers when it is going to perform this installation technique, there is a problem by which an element will be destroyed in this ** with a heat sink.
[0005] Then, the need of carrying out the flattening of the side from which the ridge stripe fraction of laser is made arises. It embeds to the almost same height as a ridge stripe fraction, and considers forming and carrying out the flattening of the layer. However, in SiO2, along with the side attachment wall of the ridge section, it had to form thinly, the flattening was difficult, and selection of an embedding material was difficult.
[0006] Then, it aims at offering the ridge type semiconductor laser which has a ridge stripe on the laser structure layer which can be equal to junction down mounting, and its manufacture technique in this invention.

[Translation done.]

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2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

MEANS

[The means for solving a technical problem] The process which this invention is the manufacture technique of the ridge type semiconductor laser which has a ridge stripe on a laser structure layer, and forms the laser substrate which carried out the laminating of the clad layer and the required contact layer of a ridge stripe material to order on a laser structure layer, The process which forms the stripe electrode of a ridge stripe pattern on the aforementioned clad layer and a required contact layer that the ridge stripe which projects from a both-sides flat part and these, and has the flat top section should be formed, The process which carries out the etching of the parts for a clad layer other than the clad layer covered by the aforementioned stripe electrode, and forms a ridge stripe and a both-sides flat part, The process which forms the embedding layer which deposits the polycrystal insulating material which makes a principal component AlN which has a refractive index lower than the refractive index of a laser structure layer on the aforementioned both-sides flat part, and sandwiches the aforementioned ridge stripe, It is characterized by including the process which removes the layer on the aforementioned stripe electrode, is made to expose the aforementioned stripe electrode, and forms the flat top section, and the process which forms an electrode on the aforementioned flat top section.
[0008] In the manufacture technique of the semiconductor laser of this invention, it is characterized by being the multilayer to which the aforementioned laser structure layer makes a principal component 1(AlxGa1-x)-yInyN (0<=x<=1, 0<=y<=1). In the manufacture technique of the semiconductor laser of this invention, it is characterized by the aforementioned embedding stratification process including a spatter process.
[0009] The semiconductor laser of this invention is characterized by having the embedding layer which deposits the polycrystal insulating material which makes a principal component AlN which has a refractive index lower than the refractive index of ridge type semiconductor laser ****** which has a both-sides flat part and the ridge stripe which has the flat top section which is projected from these, and by which an electrode is formed on a laser structure layer, and a laser structure layer on the aforementioned both-sides flat part, and sandwiches the aforementioned ridge stripe.
[0010]
[Gestalt of implementation of invention] Hereafter, the example of this invention is explained, referring to a drawing. First, the ridge stripe embedding technique in the n type semiconductor layer in the ridge type semiconductor laser which has a ridge stripe is explained. Ridge type semiconductor laser is shown in drawing 1 . This ridge

type semiconductor laser has the laser structure which consists of the clad layer 3 of n type AlGaN, the guide layer 4 of n type GaN, the barrier layer 5 of InGaN, a guide layer 6 of p type GaN, and a clad layer 7 of p type AlGaN. A laser structure layer is a multilayer which makes a principal component 1(AlxGa1-x)-yInyN (0<=x<=1, 0<=y<=1). In order to form this laser structure layer on the silicon on sapphire 1 in which the current path layer 2 of n type GaN was formed and to shut up light, the ridge stripe 15 for which the clad layer 7 of p type AlGaN projects from the both-sides flat part 14 into which it was etched, and these is formed on the laser structure layer. Moreover, the contact layer 8 of p type GaN, and the stripe-like 2nd electrode 40 are formed in the flat top section of the ridge stripe 15, and the p lateral electrode 30 is further formed on it.

[0011] This ridge type semiconductor laser has the embedding layer 21 which sandwiches the ridge stripe 15 which deposited the polycrystal insulating material which makes a principal component AlN which has a refractive index lower than the refractive index of a laser structure layer on the both-sides flat part 14. Although the polycrystal insulating material which makes AlN of this embedding layer a principal component was AlN in this example, in the case of the III-V group of the usual conventional material system used for semiconductor laser, the laser itself and the thing of large composition of the band gap of the same crystal material system were used as an insulating material for embedding layer 21 of the above. Since the refractive index became small, large composition of a band-gap value also produced the effective-refractive-index step by this, and was also able to perform eye ********.

[0012] Moreover, since perfect grid matching was conventionally acquired between the embedding layer 21 and laser structure in the case of the material system, the epitaxial re-growth without the continuous crystal defect was possible. In the case of the conventional nitride semiconductor laser, the material composition which should be used for the embedding layer 21 is AlxGa1-xN, to proportion y of AlyGa1-yN of the clad layer in which this proportion x constitutes laser structure, unless it is x>y, a desirable light closes and eye ** is not obtained. Generally, in AlzGa1-zN, unlike AlGaAs system, a lattice constant becomes small with the increase in proportion z. Therefore, a tensile stress strong against the embedding layer 21 will occur. Consequently, a crack will occur at the time of re-growth of the embedding layer 21, and a crack will be spread also for the ridge stripe 15. A crack occurs because it is made to form by the epitaxial growth grids connected and grow up to be.

[0013] Although what is necessary will be just to form the conventional embedding layer 21 by SiO2 (glassy) etc., there are three problems in this case. Heat conduction bad (0.014 W/cmK) very much, and SiO2 checks [1st] thermolysis of semiconductor laser. The coefficient of thermal expansion of SiO2 gives [2nd] distortion extremely to the semiconductor laser element itself by the parvus's (5x10-7 deg-1). The expansion coefficient of GaN is 5.6x10-6. It is because it is deg-1. Therefore, SiO2 thickness cannot be thickened but the flattening is difficult. a refractive-index difference is too large and the refractive index of SiO2 tends to become [3rd] too (about 1.46) small a high order (width -- high order) mode oscillation

[0014] Then, at the semiconductor laser of this invention, it is going to perform this embedding by the polycrystal insulating material which makes AlNs, such as AlN of a polycrystal, a principal component. Since the embedding layer 21 is polycrystal, the

crack by the difference of a lattice constant does not occur between AlGaN fractions which are laser structure. The physical-properties value of an embedding layer material is shown in Table 1.

[0015]

[Table 1]

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[0016] As mentioned above, since the advantage of this invention which used AlN for the embedding layer 21 is good, its thermal conductivity is advantageous to thermolysis, and it is more moderate than a low refractive index and SiO2 from GaN at the high refractive index. [of thermal conductivity] Moreover, occurrence of asymmetry according [a coefficient of thermal expansion] to quite near and heat is suppressed by GaN of laser structure. Since AlN is a nearly perfect insulator, it does not have the leak of a current and does not have the parasitic-capacitance occurrence based on excessive pn junction. Furthermore, the advantage of this invention does not have occurrence of the crack resulting from grid mismatching, in order to form the embedding layer 21 in the shape of polycrystal by the spatter technique etc. In case of the embedding process, the high equipment of a running cost like CVD kiln is unnecessary.

[0017] Below, the example of the technique of producing the semiconductor laser of GaN system is explained from drawing 2 to up to the silicon on sapphire by this invention based on drawing 10. As shown in drawing 2 , the wafer of silicon on sapphire 1 is prepared and clarification of the front face is carried out by the organic solvent etc. on it first, by the predetermined epitaxial growth technique, the organic-metal vapor growth, the molecular-beam grown method, etc. The current path layer 2 of n type GaN, the clad layer 3 of n type AlGaN, the guide layer 4 of n type GaN, the barrier layer 5 of InGaN, the guide layer 6 of p type GaN, the clad layer 7 of p type AlGaN, and the contact layer 8 of p type GaN are ****ed in this order, and a laser substrate wafer is produced. Moreover, in growth of the guide layer 6, the clad layer 7, and the contact layer 8, Mg is doped that it should consider as p type. In addition, you may prepare AlN buffer layer (not shown) between silicon on sapphire 1 and the current path layer 2 of n type GaN.

[0018] Next, since the layer which carried out Mg dope is insulation if it remains as it is, it heat-treats a substrate wafer in N2 gas, and forms the guide layer 6, the clad layer 7, and the contact layer 8 into p mold. Next, nickel is made to -ed ** by resistance heating vacuum evaporationo all over contact layer of wafer 8. Next, as shown in drawing 3 , patterning of the nickel layer 9 is carried out using the usual process by the photoresist and wet etching.

[0019] Next, as shown in drawing 4 , reactive ion etching (RIE) using Cl2 gas performs dry etching, using the nickel layer 9 as a mask, it removes to the clad layer 3 of n type AlGaN, and the current path layer 2 of n type GaN is exposed. Next, a photoresist layer is applied, and by wet etching, as shown in drawing 5 , the pattern of the photoresists 17a and 17b for formation of the fraction which should serve as a

ridge stripe, p lateral-electrode section, and n lateral-electrode section is made. Especially photoresist 17a leaves predetermined width of face for the nickel layer 9, and it is used in order to form the 2nd electrode 40 of the shape of a stripe of nickel layer.
[0020] Next, as shown in drawing 6 , the 2nd electrode 40 of photoresist 17a and nickel is used as a mask, by the dry etching of RIE using Cl2 gas, the etching of a part of contact layer 8 of p type GaN and clad layer 7 of p type AlGaN is carried out, and the stripe 15 of the ridge section is formed. At this time, etching is stopped in the middle of the clad layer 7 of p type AlGaN.
[0021] Next, as shown in drawing 7 , it forms so that a polycrystal AlN layer may be made to deposit to the level of the top of the 2nd electrode 40, that is, the embedding layer 21 and the 2nd electrode 40 of the ridge stripe 15 may become the same height by the reactive sputtering system using aluminum target, N2 gas, and Ar gas. Next, as shown in drawing 8 , elimination liquid removes photoresists 17a and 17b, this removes AlN layer which suited on each resist pattern by the lift off, and the 2nd electrode 40 of nickel and a part of current path layer 2 of n type GaN are exposed.
[0022] next -- the nickel 2nd electrode 40 top exposed as shown in drawing 9 -- for the n lateral electrode 31, vacuum deposition of the electrode material is carried out to the order of Ti and Au on the current path layer 2 of n type GaN in the order of Cr and Au for the p lateral electrode 30, and electrode formation is carried out, respectively Then, semiconductor laser is completed by the predetermined process.

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DESCRIPTION OF DRAWINGS

[An easy explanation of a drawing]
[Drawing 1] It is the outline perspective diagram of semiconductor laser.
[Drawing 2] It is the outline cross section of the laser substrate in the manufacturing process of the semiconductor laser of the example by this invention.
[Drawing 3] It is the outline cross section of the laser substrate in the manufacturing process of the semiconductor laser of the example by this invention.
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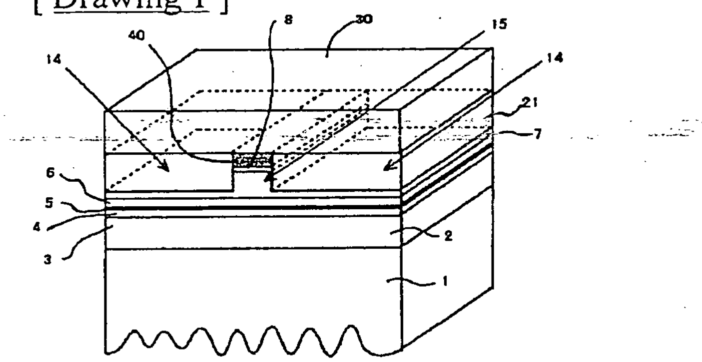
[Drawing 7] It is the outline cross section of the laser substrate in the manufacturing process of the semiconductor laser of the example by this invention.
[Drawing 8] It is the outline cross section of the laser substrate in the manufacturing process of the semiconductor laser of the example by this invention.
[Drawing 9] It is the outline cross section of the laser substrate in the manufacturing process of the semiconductor laser of the example by this invention.
[An explanation of the sign of main fractions]
1 Silicon on Sapphire
2 Current Path Layer of N Type GaN
3 Clad Layer of N Type AlGaN
4 Guide Layer of N Type GaN
5 Barrier Layer of InGaN
6 Guide Layer of P Type GaN
7 Clad Layer of P Type AlGaN
8 Contact Layer of P Type GaN
14 Both-Sides Flat Part
15 Ridge Stripe
15a Flat top section
17a, 17b Resist layer
21 Embedding Layer
30, 31 P lateral electrode
40 2nd Electrode

[Translation done.]

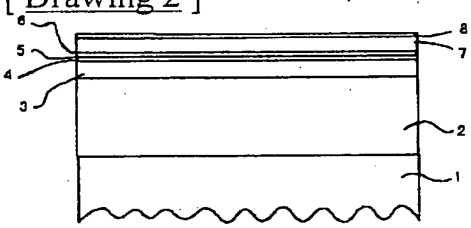
* NOTICES *

DRAWINGS

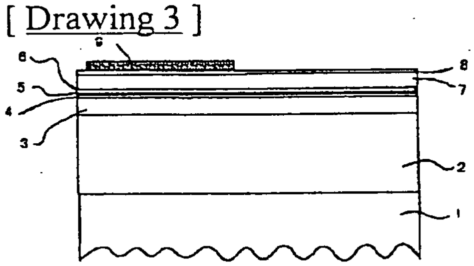
[Drawing 1]



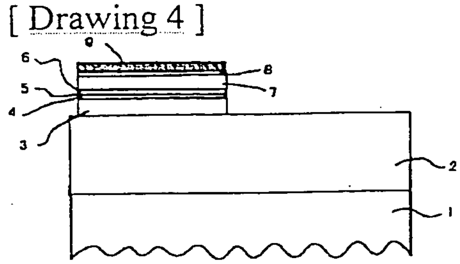
[Drawing 2]



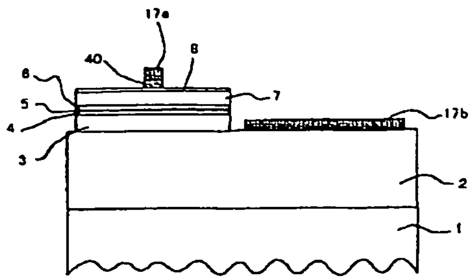
[Drawing 3]



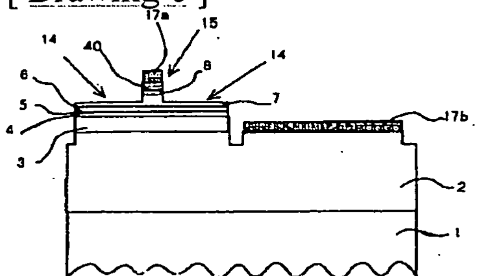
[Drawing 4]



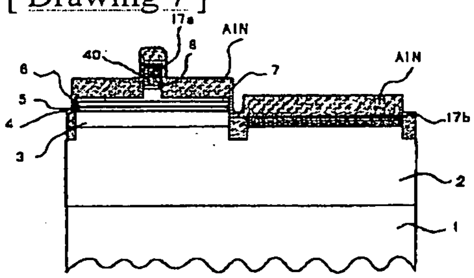
[Drawing 5]



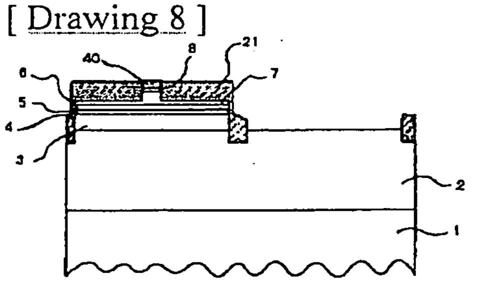
[Drawing 6]



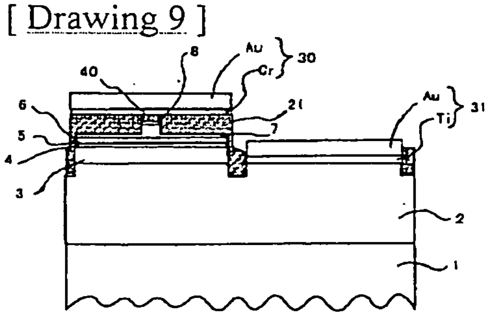
[Drawing 7]



[Drawing 8]



[Drawing 9]



[Translation done.]

(19)日本国特許庁（JP）　(12) 公開特許公報（A）　(11)特許出願公開番号
特開2000－188440
（P2000－188440A）
(43)公開日　平成12年7月4日(2000.7.4)

(51)Int.Cl.⁷	識別記号	FI		テーマコード（参考）
H01S　5/227		H01S　3/18	665	5F041
H01L　33/00		H01L　33/00	C	5F073

審査請求　未請求　請求項の数6　OL　（全6頁）

(21)出願番号　特願平10－365645
(22)出願日　平成10年12月22日(1998.12.22)

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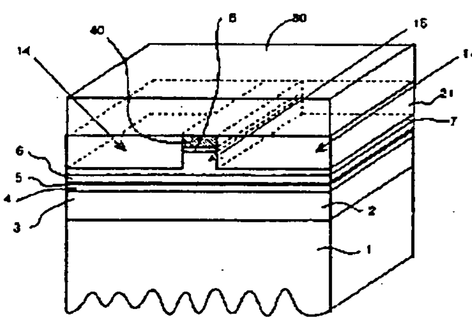
Fターム(参考)　5F041 AA33 AA44 CA34 CA65 DA04
5F073 AA13 AA45 CA07 CB05 DA05
DA25 EA28

(54)【発明の名称】　半導体レーザ及びその製造方法

(57)【要約】
【課題】　ジャンクションダウンマウントに耐え得るレーザ構造層上にリッジストライプを有するリッジ型半導体レーザ及びその製造方法を提供する。
【解決手段】レーザ構造層上にリッジストライプを有するリッジ型半導体レーザの製造方法であって、レーザ構造層上にリッジストライプ材料のクラッド層及び必要なコンタクト層を順に積層したレーザ基板を形成する工程と、両側平坦部とこれらから突出し平坦上面部を有するリッジストライプとを形成すべく、リッジストライプパターンのストライプ電極をクラッド層及び必要なコンタクト層上に形成する工程と、ストライプ電極で覆われたクラッド層以外のクラッド層部分を食刻してリッジストライプ及び両側平坦部を形成する工程と、レーザ構造層の屈折率より低い屈折率を有するＡｌＮを主成分とする多結晶絶縁材料を両側平坦部上に堆積してリッジストライプを挟む埋め込み層を形成する工程と、ストライプ電極を露出せしめ平坦上面部を形成する工程と、平坦上面部上に電極を形成する工程と、を含む。



【特許請求の範囲】

【請求項１】　レーザ構造層上にリッジストライプを有するリッジ型半導体レーザの製造方法であって、

レーザ構造層上にリッジストライプ材料のクラッド層及び必要なコンタクト層を順に積層したレーザ基板を形成する工程と、

両側平坦部とこれらから突出し平坦上面部を有するリッジストライプとを形成すべく、リッジストライプパターンのストライプ電極を前記クラッド層及び必要なコンタクト層上に形成する工程と、

前記ストライプ電極で覆われたクラッド層以外のクラッド層部分を食刻してリッジストライプ及び両側平坦部を形成する工程と、

レーザ構造層の屈折率より低い屈折率を有するＡｌＮを主成分とする多結晶絶縁材料を前記両側平坦部上に堆積して前記リッジストライプを挟む埋め込み層を形成する埋め込み層形成工程と、

前記ストライプ電極上の層を除去し前記ストライプ電極を露出せしめ平坦上面部を形成する工程と、

前記平坦上面部上に電極を形成する工程と、を含むことを特徴とする半導体レーザ製造方法。

【請求項２】　前記レーザ構造層が$(Al_xGa_{1-x})_{1-y}In_yN$（$0\leqq x\leqq 1$、$0\leqq y\leqq 1$）を主成分とする多層であることを特徴とする請求項１記載の半導体レーザ製造方法。

【請求項３】　前記埋め込み層形成工程はスパッタ工程を含むことを特徴とする請求項１又は２記載の半導体レーザ製造方法。

【請求項４】　レーザ構造層上に、両側平坦部と、これらから突出し電極が形成される平坦上面部を有するリッジストライプと、を有するリッジ型半導体レーザあって、

レーザ構造層の屈折率より低い屈折率を有するＡｌＮを主成分とする多結晶絶縁材料を前記両側平坦部上に堆積して前記リッジストライプを挟む埋め込み層を有することを特徴とする半導体レーザ。

【請求項５】　前記レーザ構造層が$(Al_xGa_{1-x})_{1-y}In_yN$（$0\leqq x\leqq 1$、$0\leqq y\leqq 1$）を主成分とする多層であることを特徴とする請求項４記載の半導体レーザ。

【請求項６】　前記ＡｌＮを主成分とする多結晶絶縁材料はＡｌＮであることを特徴とする請求項４又は５記載の半導体レーザ。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、半導体レーザ及びその製造方法に関する。

【０００２】

【従来の技術】半導体レーザは、光ディスクから信号を読み出し／書込む光学式情報記録再生装置における光ピ

ックアップ装置の光源に用いられる他に、光ＣＡＴＶなどの光通信システムや、高密度情報記録ＳＨＧ短波長レーザ、又は小型固体レーザのポンプ光源や、光計測分野などに応用され得る素子として知られている。小電流で動作し横方向単一モード発振を行うためには半導体中の電子及び正孔並びに発振光を小さい領域に閉じこめる必要がある。pn接合垂直方向ではダブルヘテロ構造などで閉じこめている。接合に平行な方向に関して、レーザの発光領域を制限する方法として利得導波構造があるが、これは一般に波面がゆがみ、非点収差が出てしまうため、ディスク読取り用光源の用途などでは、屈折率導波構造の半導体レーザが使われる。屈折率導波構造は、接合垂直方向だけでなく、リッジストライプを形成するなどして接合平行方向でも屈折率の低いクラッド材料で発光領域を挟む構造である。

【０００３】電流注入領域の部分以外のクラッド層の一部をエッチングなどで除去し、リッジストライプを形成するとリッジ下部のガイド層を伝搬する光に対する実効屈折率が、それ以外の部分より、若干大きくなるため、リッジ下部部分に光が閉じ込められる。リッジ型半導体レーザでは、リッジ上部に電極を設け、電極及び基板間に電流を注入して発振させる。

【０００４】

【発明が解決しようとする課題】一方、半導体レーザを連続発振で使用する場合に問題になるのが、熱の発生である。そこで放熱を良くするため、リッジ上部の電極をヒートシンクに接触させる、いわゆるジャンクションダウンのマウントが行なわれる。この載置方法を行なおうとすると、突出しているリッジ部分の幅がわずか数μmのため、ヒートシンクとの当接にて素子が破壊されてしまう問題がある。

【０００５】そこで、レーザのリッジストライプ部分が作られている側を平坦化する必要が生ずる。リッジストライプ部分とほぼ同じ高さまで埋め込み層を形成して平坦化することが考えられている。しかし、SiO_2などではリッジ部の側壁に沿って薄く形成しなければならず平坦化が困難で、埋め込み材料の選択が難しいものであった。

【０００６】そこで、本発明では、ジャンクションダウンマウントに耐え得るレーザ構造層上にリッジストライプを有するリッジ型半導体レーザ及びその製造方法を提供することを目的とする。

【０００７】

【課題を解決するための手段】本発明は、レーザ構造層上にリッジストライプを有するリッジ型半導体レーザの製造方法であって、レーザ構造層上にリッジストライプ材料のクラッド層及び必要なコンタクト層を順に積層したレーザ基板を形成する工程と、両側平坦部とこれらから突出し平坦上面部を有するリッジストライプとを形成すべく、リッジストライプパターンのストライプ電極を

前記クラッド層及び必要なコンタクト層上に形成する工程と、前記ストライプ電極で覆われたクラッド層以外のクラッド層部分を食刻してリッジストライプ及び両側平坦部を形成する工程と、レーザ構造層の屈折率より低い屈折率を有するＡｌＮを主成分とする多結晶絶縁材料を前記両側平坦部上に堆積して前記リッジストライプを挟む埋め込み層を形成する工程と、前記ストライプ電極上の層を除去し前記ストライプ電極を露出せしめ平坦上面部を形成する工程と、前記平坦上面部上に電極を形成する工程と、を含むことを特徴とする。

【０００８】本発明の半導体レーザの製造方法においては、前記レーザ構造層が $(Al_xGa_{1-x})_{1-y}In_yN$（$0 \leq x \leq 1$、$0 \leq y \leq 1$）を主成分とする多層であることを特徴とする。本発明の半導体レーザの製造方法においては、前記埋め込み層形成工程はスパッタ工程を含むことを特徴とする。

【０００９】本発明の半導体レーザは、レーザ構造層上に、両側平坦部と、これらから突出し電極が形成される平坦上面部を有するリッジストライプと、を有するリッジ型半導体レーザあって、レーザ構造層の屈折率より低い屈折率を有するＡｌＮを主成分とする多結晶絶縁材料を前記両側平坦部上に堆積して前記リッジストライプを挟む埋め込み層を有することを特徴とする。

【００１０】

【発明の実施の形態】以下、本発明の実施例を図面を参照しつつ説明する。まず、リッジストライプを有するリッジ型半導体レーザにおける、ｎ型の半導体層でのリッジストライプ埋め込み方法を説明する。図１にリッジ型半導体レーザを示す。このリッジ型半導体レーザは、ｎ型ＡｌＧａＮのクラッド層３、ｎ型ＧａＮのガイド層４、ＩｎＧａＮの活性層５、ｐ型ＧａＮのガイド層６及びｐ型ＡｌＧａＮのクラッド層７からなるレーザ構造を有している。レーザ構造層は $(Al_xGa_{1-x})_{1-y}In_yN$（$0 \leq x \leq 1$、$0 \leq y \leq 1$）を主成分とする多層である。このレーザ構造層はｎ型ＧａＮの電流経路層２が形成されたサファイア基板１上に形成され、光を閉じこめるために、ｐ型ＡｌＧａＮのクラッド層７がエッチングされた両側平坦部１４とこれらから突出するリッジストライプ１５とがレーザ構造層上に形成されている。また、リッジストライプ１５の平坦上面部にはｐ型ＧａＮのコンタクト層８及びストライプ状の第２電極４０が形成され、さらにその上にｐ側電極３０が形成されている。

【００１１】このリッジ型半導体レーザは、レーザ構造層の屈折率より低い屈折率を有するＡｌＮを主成分とす＊

＊る多結晶絶縁材料を両側平坦部１４上に堆積したリッジストライプ１５を挟む埋め込み層２１を有している。本実施例では、この埋め込み層のＡｌＮを主成分とする多結晶絶縁材料はＡｌＮであるが、半導体レーザに用いられる通常の従来材料系のIII－V族の場合、上記の埋め込み層２１用の絶縁材料として、レーザそのものと同様な結晶材料系のバンドギャップの大きい組成のものを用いていた。バンドギャップ値の大きい組成は屈折率が小さくなるので、これにより実効屈折率ステップも生じて、光閉じ込めも行なえた。

【００１２】また、従来材料系の場合、埋め込み層２１と、レーザ構造との間で完全な格子整合を得ることができたので、連続した結晶欠陥のないエピタキシャル再成長が可能であった。従来の窒化物半導体レーザの場合、埋め込み層２１に用いるべき材料組成は $Al_zGa_{1-z}N$ で、この比率ｚはレーザ構造を成すクラッド層の $Al_yGa_{1-y}N$ の比率ｙに対し、$z > y$ でない限り、望ましい光の閉じ込めが得られない。一般に、$Al_zGa_{1-z}N$ の場合、ＡｌＧａＡｓ系とは異なり、比率ｚの増加と共に格子定数が小さくなる。従って、埋め込み層２１には強い引っ張り応力が発生してしまう。この結果、埋め込み層２１の再成長時にクラックが発生してしまい、クラックはリッジストライプ１５にも伝搬してしまうことになる。クラックが発生するのは、格子同士がつながって成長するエピタキシャル成長で形成させるからである。

【００１３】従来の埋め込み層２１を例えば SiO_2（ガラス質）などで形成すれば良いことになるが、この場合、３つの問題がある。第１に、SiO_2 は熱伝導が極めて悪い（０．０１４　W/cmK）ので、半導体レーザの放熱を阻害する。第２に、SiO_2 の熱膨張係数が極めて小さい（5×10^{-7} deg^{-1}）ので、半導体レーザ素子自体に歪を与える。ＧａＮの膨張係数は 5.6×10^{-6} deg^{-1} であるからである。よって、SiO_2 膜厚を厚くできず平坦化が困難である。第３に、SiO_2 の屈折率が小さすぎる（１．４６程度）ので、屈折率差が大きすぎて、高次（横高次）モード発振になり易い。

【００１４】そこで、本発明の半導体レーザでは、多結晶のＡｌＮなどのＡｌＮを主成分とする多結晶絶縁材料でこの埋め込みを行なおうとするものである。埋め込み層２１が多結晶なので、レーザ構造であるＡｌＧａＮ部分との間で格子定数の差によるクラックが発生しない。埋め込み層材料の物性値を表１に示す。

【００１５】

【表１】

	熱伝導率	熱膨張係数	屈折率
ＡｌＮ（単結晶）	2.85 W/cmK	-	2.15
ＡｌＮ（多結晶）	1.7 W/cmK	4.3×10^{-6} deg^{-1}	
SiO_2	0.014 W/cmK	5×10^{-7} deg^{-1}	1.46
ＧａＮ（単結晶）	1.3 W/cmK	5.6×10^{-6} deg^{-1}	2.8

また、AlNは、通常、絶縁体であるので、埋め込み層21はまったく電流を通さない。したがって、従来のようにn型半導体で埋め込んだ場合に生ずる寄生容量の問題も生じにくい。

【0016】以上、埋め込み層21にAlNを用いた本発明の利点は、熱伝導率が良いので、放熱に有利であり、GaNより低屈折率かつSiO_2より高屈折率で適度である。また、熱膨張係数がレーザ構造のGaNにかなり近く、熱による歪みの発生が抑制される。AlNはほぼ完全な絶縁体なので、電流のもれが全くなく、余分なpn接合に基づく寄生容量発生がない。さらに、本発明の利点は、埋め込み層21をスパッタ方法などで多結晶状に形成するため、格子不整合に起因するクラックの発生がない。埋め込み工程に際し、CVD炉のようなランニングコストの高い装置が不要である。

【0017】以下に、本発明によるサファイア基板上へGaN系の半導体レーザを作製する方法の実施例を図2から図10に基づいて説明する。まず、図2に示すように、サファイア基板1のウエハを用意し、有機溶媒などで表面を清浄し、その上に、所定のエピタキシャル成長方法、有機金属気相成長法、分子線成長法などで、n型GaNの電流経路層2、n型AlGaNのクラッド層3、n型GaNのガイド層4、InGaNの活性層5、p型GaNのガイド層6、p型AlGaNのクラッド層7、及びp型GaNのコンタクト層8を、この順で成膜し、レーザ基板ウエハを作製する。また、ガイド層6、クラッド層7及びコンタクト層8の成長ではp型とすべくMgのドープを行っている。なお、サファイア基板1及びn型GaNの電流経路層2の間にAlNバッファ層（図示せず）を設けてもよい。

【0018】次に、Mgドープした膜はそのままでは絶縁性なので、基板ウエハを、N_2ガス中で熱処理して、ガイド層6、クラッド層7及びコンタクト層8をp型化する。次に、ウェハのコンタクト層8全面に抵抗加熱蒸着でNiを被着させる。次に、図3に示すように、フォトレジストとウェットエッチングによる通常のプロセスを用いて、Ni膜9をパターニングする。

【0019】次に、図4に示すように、Ni膜9をマスクとして、Cl_2ガスを用いた反応性イオンエッチング（RIE）によりドライエッチングを行なって、n型AlGaNのクラッド層3まで除去してn型GaNの電流経路層2を露出させる。次に、フォトレジスト膜を塗布して、ウェットエッチングにより、図5に示すように、リッジストライプ及びp側電極部並びにn側電極部となるべき部分の形成用のフォトレジスト17a、17bのパターンを作る。特に、フォトレジスト17aはNi膜9を所定幅を残して、Ni膜のストライプ状の第2電極40を形成するために用いられる。

【0020】次に、図6に示すように、フォトレジスト17a及びNiの第2電極40をマスクとしてCl_2ガスを用いたRIEのドライエッチングにより、p型GaNのコンタクト層8及びp型AlGaNのクラッド層7の一部を食刻して、リッジ部のストライプ15を形成する。この時、p型AlGaNのクラッド層7の途中でエッチングを停止する。

【0021】次に、図7に示すように、反応性スパッタリング装置により、Alターゲット並びにN_2ガス及びArガスを用いて、多結晶AlN膜を、第2電極40の上面のレベルまで堆積させ、つまり埋め込み層21とリッジストライプ15の第2電極40とが同じ高さになるように形成する。次に、図8に示すように、フォトレジスト17a、17bを除去液で除去し、これにより、各レジストパターン上にあったAlN膜をリフトオフで除去し、Niの第2電極40及びn型GaNの電流経路層2の一部を露出させる。

【0022】次に、図9に示すように、露出したNi第2電極40上にはp側電極30のためにCr、Auの順で、n側電極31のためには、Ti、Auの順に電極材をn型GaNの電流経路層2上に真空蒸着して、それぞれ電極形成する。その後、所定工程により、半導体レーザが完成される。

【図面の簡単な説明】

【図1】半導体レーザの概略斜視図である。

【図2】本発明による実施例の半導体レーザの製造工程中におけるレーザ基板の概略断面図である。

【図3】本発明による実施例の半導体レーザの製造工程中におけるレーザ基板の概略断面図である。

【図4】本発明による実施例の半導体レーザの製造工程中におけるレーザ基板の概略断面図である。

【図5】本発明による実施例の半導体レーザの製造工程中におけるレーザ基板の概略断面図である。

【図6】本発明による実施例の半導体レーザの製造工程中におけるレーザ基板の概略断面図である。

【図7】本発明による実施例の半導体レーザの製造工程中におけるレーザ基板の概略断面図である。

【図8】本発明による実施例の半導体レーザの製造工程中におけるレーザ基板の概略断面図である。

【図9】本発明による実施例の半導体レーザの製造工程中におけるレーザ基板の概略断面図である。

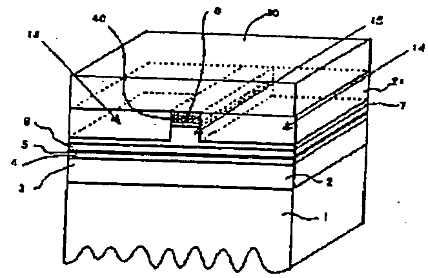
【主要部分の符号の説明】

1　サファイア基板
2　n型GaNの電流経路層
3　n型AlGaNのクラッド層
4　n型GaNのガイド層
5　InGaNの活性層
6　p型GaNのガイド層
7　p型AlGaNのクラッド層
8　p型GaNのコンタクト層
14　両側平坦部
15　リッジストライプ

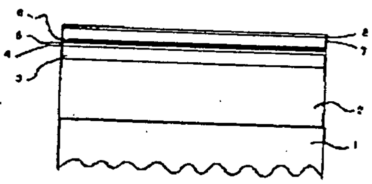
１５ａ　平坦上面部
１７ａ、１７ｂ　レジスト層
２１　埋め込み層

＊３０，３１　Ｐ側電極
４０　第２電極
＊

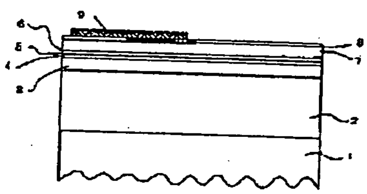
【図１】



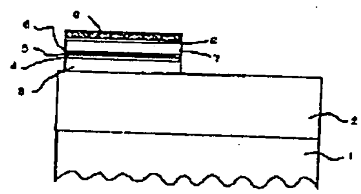
【図２】



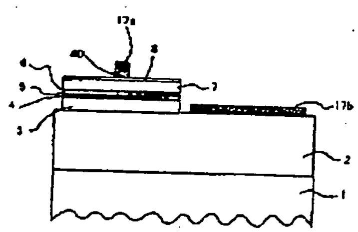
【図３】



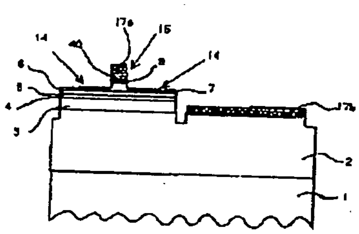
【図４】



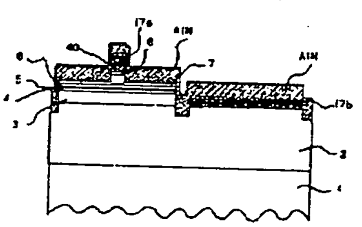
【図５】



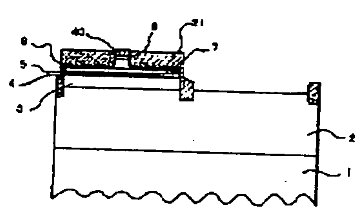
【図６】



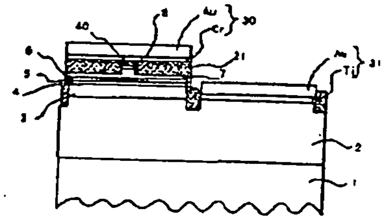
【図７】



【図８】



【図9】



DOCKET NO: P2001,0678
SERIAL NO:
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